Sugarcane workers: Morbidity and mortality

F DeWolfe Miller MPH PhD*
Dwayne M Reed MD PhD**
James Banta MD***

Sugarcane is, after pineapple, the largest agricultural industry in Hawaii. There have been reports that this industry poses certain health hazards. To investigate this possible hazard in Hawaii, the relationship of employment on a sugarcane plantation to total mortality, the development of definite coronary heart disease (CHD), stroke, cancer, lung cancer and certain risk factors were examined in men of Japanese ancestry participating in the Honolulu Heart Program. After 18 years of follow-up, those men who indicated one or more years working on sugarcane plantations had no significant difference in age-adjusted mortality, nor incidence of CHD, stroke, cancer, or lung cancer. There were no differences in risk factors compared to participants who were never employed on sugarcane plantations, nor were there differences in lung function as measured by FEV_1. These findings were unchanged after adjusting for several potential confounding variables. No cases of mesothelioma were observed among those with a history of defined exposure. These findings were not due to a "healthy worker bias" and indicate that employment on a sugarcane plantation in Hawaii is not associated with elevated rates of chronic diseases.

Introduction

Prior data on the occupational risks of employment on sugarcane plantations have not been subject to much research. There is a defined occupational pneumoconiosis, bagassosis, that is known to occur among those who work with or around moldy bagasse (the remnants of sugarcane after sugar extraction)[4,5]. Das et al[3], Gottlieb et al[6], and Rothschild and Mulvey[14], have reported either lung cancer or mesothelioma among sugarcane plantation workers. Steineck et al[16] found increases in mesothelioma in sugar refinery workers.

In Hawaii prior to harvesting, growing sugarcane is burned to reduce leafage and improve sugar recovery. Newman[10-12] has identified fibers in the smoke from sugarcane that resemble asbestos fibers. His findings imply that those exposed to sugarcane smoke during the routine burning and harvesting of sugarcane fields can be at greater risk of lung cancer, mesothelioma or pneumoconiosis.

The objective of our study was to investigate the possible relationship between working on a sugarcane plantation and the incidence of definite coronary heart disease (CHD) cancer. We also sought a possible relationship between this occupation and risk factors using the cohort from the Honolulu Heart Program (HHP).

* From the Department of Public Health Sciences, School of Public Health, University of Hawaii, Honolulu, Hawaii 96822
** The Honolulu Heart Program, National Heart, Lung and Blood Institute, Honolulu, Hawaii 96817
+ 146 G Street, SW Washington, DC 20024

Address reprint request to Dr. Miller, Department of Public Health Sciences, School of Public Health, University of Hawaii, Honolulu, Hawaii 96826. Telephone (808) 956-5739 and Fax (808) 956-9793

Methods

Defining of the study population

The HHP cohort was first established in 1965 and was comprised of men of Japanese ancestry born between 1900 and 1919 who were residents of Oahu at the time of the baseline examination. Between 1965 and 1968, 8,006 men participated out of the 11,148 who were known to be eligible as identified in the World War II Selective Service list.

Occupational classification

Prior to the first examination letters were sent to each subject person explaining the study and asking certain questions. Some of these questions referred to employment. There were 9 employment categories, one of which was "sugar industry". This information was coded.

At the baseline examination, an interviewer asked each participating member of the cohort what was his present and his usual occupation and how many years he had been employed in each job. Specific questions were asked as to whether he worked in the field or elsewhere. The duration of sugar plantation employment was recorded at a third follow-up examination 6 years after the baseline examination.

A plethora of occupational information was therefore available for analysis. Two occupational variables showed up: The first variable included all those working at least one or more years on sugarcane plantations (n=2537). There was a total of 5,300 individuals in the cohort about whom this information existed. The second variable was our stratification of the first according to the number of years worked; zero (did not work on the sugarcane plantations), 1 to 5 years, 6 to 10, and 11+ (n=2763, 1903, 422 and 212 subjects respectively). Data on specific job activity within the sugarcane plantations were not available.

Risk factors

At the initial examination of the persons in the cohort measurements of blood pressure, FEV_1, body mass index (kg/height in m^2=square meters) and serum cholesterol were made on each participant.

The interviewer also inquired about smoking habits and alcohol consumption. Smoking was recorded as the number of cigarettes per day times the number of years smoked, converted to cigarette-years. The number of ounces of ethanol per month was estimated using conversion factors as specified in *USDA Handbook No. 8*[17].

Outcomes and diagnostic criteria

Prevalent cases of definite coronary heart disease, stroke and cancer were identified at baseline. Of the 8,006 men examined

at baseline, 456 had existing disease and were excluded from follow-up. This left 7, 550 men for follow-up, of which 1, 824 had died by December 31, 1987. Data on specific cause of death and incidence of fatal and non-fatal CHD, stroke and cancer were available over an 18-year follow-up period.

Ascertainment of morbidity and mortality was obtained from 2 additional follow-up exams completed 2 and 6 years after the first exam and by a comprehensive surveillance system of hospital discharge records on the island of Oahu[8]. The cause of death of all HHP members was determined by consensus of a panel of study physicians.

The definition of CHD included non-fatal myocardial infarction, CHD death and sudden death within 1 hour. Thromboembolic or hemorrhagic stroke as defined by a neurologist in the panel was based on clinical, surgical and/or autopsy findings. In addition, cancer incidence was determined by a review of new tumor accessions at the Hawaii Tumor Registry. Thus data on causes of death and incidence of cardiovascular disease and cancer were available for an 18-year follow-up period.

Statistical analyses

Life table analyses were employed to estimate comparative incidence rates of CHD, stroke, cancer and total mortality. All comparisons between the "exposed" and not "exposed" were adjusted for age and, when appropriate, for other risk factors such as alcohol and smoking by a covariance method using a proportional hazards model[2]. Estimates of the mean of risk factors in categories of occupation were also compared and adjusted for age by the covariance method, using standard ANOVA models.

Results

Table 1 shows the results in age-adjusted mortality rates for each of the 2 occupational variables. There was no significant increase in risk among those working 1 year or more on sugarcane plantations nor was there any significant pattern with increasing years of work on sugarcane plantations in terms of total mortality.

The incidence of relative risk of definite CHD and of mortality because of working on sugarcane plantations were very close to 1, as shown in Table 2. None of the 95% confidence intervals showed relative risk significantly different from unity. Similar patterns can be seen in Tables 3, 4, and 5 in stroke, total cancer and lung cancer respectively. There were no mesothelioma cases among any of those occupations defined as sugarcane workers.

Some occupations can be linked to the risk of chronic diseases indirectly through risk factors such as blood pressure, serum cholesterol, body mass, tobacco, alcohol consumption and lung function. The changes in these risk factors can be more sensitive predictors of exposure to airborne particulates generated during sugarcane cultivation and harvesting than incidental disease.

The results in comparing risk factors and sugarcane plantation employment are shown in Table 6. The age-adjusted values by employment-variables were essentially the same. The sugar workers did have a slightly better FEV_1, but this was not statistically significant. The mean FEV values were adjusted for the degrees of cigarette smoking. This did not change the results; the smoking habits were not significantly different between the sugar plantation workers and non-plantation workers.

These results indicate that those who had worked on sugar plantations experienced similar rates of the most common chronic degenerative diseases as compared with non-plantation workers. However, most of the cohort had quit working on plantations by the time of the first examination in the late 1960s. It is possible, though unlikely, that those working on sugar plantations took jobs that were associated with low chronic disease rates and mortality, and those who never worked on plantations had taken jobs later that were associated with high rates of chronic disease and mortality. In order to address this possible bias, a frequency table of occupations at the first examination was generated to see if the sugarcane workers had preferentially selected one or more occupations.

The list of occupations has more than 400 titles and therefore is not included here. No meaningful difference in the distribution of occupations selected by the 2 groups was found. Differences in frequencies between sugar and non-sugar workers for a given occupational title were never greater than 3 percentage points. This suggests that occupations taken after working on the sugar plantations did not project a bias on the observed rates compared above.

A more specific analysis was done using the occupational classification of carpenters. We knew this was the most frequently recorded occupation in the cohort[9]. The HHP carpenters had lower CHD rates and total mortality as compared to the overall rates in the cohort. Those classified as having one or more years working on sugarcane plantations were cross-tabulated by carpentry. The cross-tabulation showed that the sugarcane workers did not preferentially select this occupation compared to the non-sugarcane workers.

Discussion

No association between sugarcane plantation employment and increased risk of CHD, stroke, cancer, lung cancer, or of total mortality was found. There were no mesothelioma cases among sugarcane workers. Moreover, the risk factors for these diseases were not elevated in the sugarcane plantation employees. Lung function results were similar to those who did not work on sugarcane plantations and did not indicate any trend to decrease with the duration of employment on the plantations. Furthermore, there was no evidence that work in other occupations could have accounted for these results.

There are several factors that influence the interpretation of these results. These factors are discussed below.

Bias due to misclassification of disease was minimized by the protocol for diagnosis in the project. Loss to follow-up was minimized by an effective surveillance system for identifying incident cases[8].

The groups for comparison were taken from the sub-populations of the HHP cohort; they were ethnically homogenous. This minimizes one of the problems in selecting comparison groups

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in occupational epidemiology. The removal of existing cases of chronic diseases at the time of baseline examination further reduces possible differences between the exposed and non-exposed groups and eliminates the "healthy worker"(HW) factor. The HW factor skews the findings when the comparison groups are taken from the general population which includes both healthy and diseased individuals.

The sugarcane industry population is ethnically heterogenous. Through the 1920s to the 1950s the sugar plantation working population has been approximately 22% Japanese[9]. The proportion of the working Japanese male populations on the different island plantations ranged from 17% to 25%. Almost 80% of the employees currently are from other ethnic groups, primarily Filipino. Our study was not designed to cover the health status of these other employees.

The data do not include the names of the sugarcane plantations or their locations. Therefore in the case of any given individual HHP cohort member, the sugarcane plantation where he was employed is not given. As mentioned above, all cohort members were residing on Oahu when the study began in the late 1960s. This indicates that the plantations were on Oahu. Hawaii Sugar Planters Association (HSPA) records show there was no significant difference in operations between the sugar plantations and the working conditions for their employees on the several islands of Hawaii (Whalen S, Archives of the Hawaii Sugar Planters Association. Personal communication. 1989).

It is unlikely that all the Japanese employees in the sugar industry had the same job description or that all Japanese employees worked in the field or were blue-collar workers.

TABLE 1: Age-Adjusted Rates per 1000 for Total Mortality during the Surveillance Period from 1956 to Dec. 31, 1987

Years Worked	N	RR	95%	CI	Rate/ 1000
1 or more					
Yes	2537	0.98	0.87	1.10	119.2
No	2763	1.00	0.00	0.00	121.6
0 to 11+					
0	2763	1.00	0.00	0.00	121.6
1 - 5	1903	0.99	0.87	1.12	120.4
6 - 10	422	0.95	0.75	1.20	115.7
11+	212	0.95	0.71	1.27	115.9

TABLE 2: Age-Adjusted Rates per 1000 for Definite CHD and Mortality for Surveillence Period from 1956 to Dec. 31, 1987

Years Worked	N	RR	95%	CI	Rate/ 1000
1 or more					
Yes	2537	1.09	0.91	1.30	85.5
No	2763	1.00	0.00	0.00	78.8
0 to 11+					
0	2763	1.00	0.00	0.00	78.8
1 - 5	1903	1.11	0.92	1.34	86.8
6 - 10	422	0.94	0.66	1.35	74.4
11+	212	1.22	0.80	1.85	95.2

TABLE 3: Age-Adjusted Rates per 1000 for Stroke and Mortality for the Surveillance Period from 1956 to Dec. 31, 1987

Years Worked	N	RR	95%	CI	Rate/ 1000
1 or more					
Yes	2537	1.08	0.85	1.36	44.1
No	2763	1.00	0.00	0.00	41.0
0 to 11+					
0	2763	1.00	0.00	0.00	41.0
1 - 5	1903	1.06	0.82	1.37	43.6
6 - 10	422	1.24	0.80	1.91	50.6
11+	212	0.92	0.49	1.69	37.6

TABLE 4: Age Adjusted Rates per 1000 for Total Cancer and Mortality for the Surveillance Period from 1956 to Dec. 31, 1987

Years Worked	N	RR	95%	CI	Rate/ 1000
1 or more					
Yes	2537	0.97	0.84	1.12	115.2
No	2763	1.00	0.00	0.00	118.6
0 to 11+					
0	2763	1.00	0.00	0.00	118.6
1 - 5	1903	0.95	0.81	1.12	113.4
6 - 10	422	0.96	0.72	1.28	114.3
11+	212	1.12	0.80	1.58	132.2

TABLE 5: Age Adjusted Rates per 1000 for Lung Cancer and Mortality for the Surveillence period from 1956 to Dec. 31, 1987

Years Worked	N	RR	95%	CI	Rate/ 1000
1 or more					
Yes	2537	1.26	0.89	1.78	19.0
No	2763	1.00	0.00	0.00	15.1
0 to 11+					
0	2763	1.00	0.00	0.00	15.1
1 - 5	1903	1.23	0.85	1.78	18.5
6 - 10	422	1.13	0.56	2.28	17.1
11+	212	1.80	0.86	3.78	27.1

TABLE 6: Age-Adjusted Risk Factors, Mean Values for the Surveillance Period from 1956 to Dec. 31, 1987

Years Worked	N	Choles-trol	SBP	FEV_1*	Cig/ Year	Alcohol	BMI
1 or more							
Yes	2537	218.1	132.9	2.74	457.9	13.1	24.1
No	2763	217.7	133.2	2.72	451.0	13.8	23.7
0 to 11+							
0	2763	217.7	133.2	2.72	451.0	13.9	23.7
1 - 5	1903	218.1	132.7	2.74	463.3	13.5	24.1
6 - 10	422	217.8	133.5	2.73	446.8	13.0	23.9
11+	212	221.6	132.8	2.74	431.6	10.5	24.4

*FEV_1 was adjusted for height and cigarette years.

Industry records suggest the Japanese employees were most likely blue-collar field or plant workers rather than white-collar office workers (Whalen S). Blue-collar or white-collar occupational status has not been found to be associated with CHD, stroke, cancer, total mortality or the related risk factors in the HHP cohort (unpublished data).

Only a few of the employees on a sugarcane plantation are exposed directly to sugarcane smoke, which is the primary source for the fibers described by Newman[10-12]. On a given plantation there are usually 1 to 4 employees trained to burn sugarcane fields. These individuals almost always set the fires with the wind at their backs, which means the wind blows the smoke away from the worker. In a given field of 40 to 60 acres, the sugarcane leaves are burned off in 20 to 40 minutes and the fire burns out in less than an hour. Although more than one field can be burned daily, the period of exposure is brief and involves a very small group of the overall plantation personnel. Exposures to other field workers have not been notable.

However, other field employees could be potentially exposed to a variety of environmental and occupational hazards. The classifications of sugarcane-plantation employment does not provide specific information as to job description, whether the employee worked indoors or outdoors, or any specific information that would specify the degree of exposure. This would tend to dilute an association, especially a weak association, resulting in a false negative conclusion. In addition, individual participants could have incorrectly reported their occupational history although each participant was asked directly by an interviewer if he was or had been working on sugarcane plantations and for how long.

Exposure was defined according to job duration in years and had a skewed distribution, ie, most of these employees were exposed for only a few years, and few employees were exposed for long periods. The analysis based on job duration did not show any particular trend in any of the outcome variables, suggesting that longer observation would not have provided any further insight. The statistically insignificant trend in lung cancer, however, warrants some measure of uncertainty in the conclusion and could justify the need for additional observations. The relative risk was very low even in the group with the highest exposure. The attributable risk, ie, the proportion of cases in the exposed group that could have had an adverse consequence prevented by removing the exposure, thus reducing the impact on public health, is small.

Bagassosis has been reported in many sugarcane-growing areas[4,5,8]. There have not been any cases of this pneumoconiosis reported in the Hawaii sugarcane industry, however. The results of the lung function tests suggest little if any pneumoconiosis occurred among HHP cohort members working on the sugarcane plantations, compared to those working elsewhere. The actual number of employees on Hawaii sugarcane plantations working with bagasse are small, probably less than 20 persons. Individual cases of pneumoconiosis, however, could have been missed.

Rothschild and Mulvey[14] reported an odds ratio of 2.4 for lung cancer on sugarcane farms in Louisiana after adjusting for smoking tobacco. The authors couched their conclusions with numerous caveats. Their hypothesis was generated by analysis of data; their interviewers were not blinded; their study was retrospective in design, and a specific causal agent was not identified. In addition, non-participation was at a rate of nearly 30%; possible selection bias in controls was not addressed; there was no clear dose response; their findings were not consistent with association of lung cancer and shipbuilding as has been reported in Louisiana and elsewhere[1,6,7,13,15]; and the 2 mesothelioma cases reported in the sugarcane farmers can be explained on the basis of chance. Perhaps most important, their report did demonstrate that the sugarcane farmers worked in sugar refineries or were otherwise exposed directly to sugarcane smoke.

Previously, Gottlieb et al[6] had completed an investigation in southern Louisiana and reported that excesses in lung cancer were related to the manufacture of transportation equipment, mainly in shipbuilding and the fishing industry. Steineck et al[16] attributed the excess in mesothelioma to asbestos in sugar refinery workers and not to organic fibers in dust. This suggests that exposure to asbestos could explain the excess lung cancers. Our results are not consistent with those reported by Rothschild and Mulvey[14] or those reported by others that indicate increased risk of lung disease or dysfunction[3,10-12].

In conclusion, the studies needed to investigate further the hazards in sugarcane work will need more specific data on exposure and on the duration of exposure over longer periods of time. Ideally, exposure data are needed based on inhalation of actual toxins by individual workers. A population defined by such exposures will need to be followed over a long time in order to determine the effects on health that could result from such exposures.

Acknowledgement

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References

1. Blot WJ, Harrington JM, Toledo A, Hoover R, Heath CW, Fraumeni JF. Lung cancer after employment in shipyards during World War II. *N Engl J Med.* 1978;299:620-624.
2. Cox DR. Regression models and life tables. With discussion. *J Royal Stat Soc.* 1972;34:187-220.
3. Das PB, Fletcher AG, Deodhare SG. Mesothelioma in an agricultural community of India: a clinicopathological study. *Aus Ne Zea Journal of Surgery.* 1976;46:218-226.
4. Dockhorn RJ, Neiburger JB. Farmers' lung disease and bagassosis. In: Frazier CA, Ed., *Occupational Asthma.* Van Nostrand Reinhold Co., 1980; pp.257-265.
5. Fink J. Hypersensitivity pneumonitis. In: Merchant JA Ed., *Occupational Respiratory Disease.* U.S. Dept. Health and Human Services. DHHS Pub. No. 86-102, 1986; pp.481-500.
6. Gottlieb MS, Pickle LW, Blot WJ, Fraumeni JF. Lung Cancer in Louisiana: Death Certificate Analysis. *JNCI.* 1979;63: 1131-1137.
7. Gottlieb MS, Stedman RB. Lung cancer in shipbuilding and related industries in Louisiana. *South Med J.* 1979;2:1099-1101 .
8. Merchant JA. Agricultural exposures to organic dusts. *Occupational*

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Medicine: State of the Art Reviews. 1987;2:409-425.
9. Miller FD, Reed D, MacLean C. A prospective study of morbidity and mortality of carpenters in the Honolulu Heart Study. *J Occup Medicine.* 1988;30:(11) 879-882.
10. Newman R. Asbestos-like fibers of biogenic silica in sugarcane. *Lancet.* 1983;2: 8354.
11. Newman R. Association of biogenic silica with disease. *J Nut Cancer.* 1986;8:217-221.
12. Newman R. Fine biogenic silica fibers in sugarcane: a possible hazard. *Ann Occupational Hyg.* 1986;30:365-370.
13. Rothschild H, Voors AW, Weed SG, Vial LJ, Welsh RA, Johnson WD. Trends in respiratory system cancer mortality in Louisiana: Geographic distribution in 1950-1969 and 1967-1976 compared. *Am J Pub Health.* 1979;69:380-381.
14. Rothschild H, Mulvey JJ. An increased risk for lung cancer mortality associated with sugarcane farming. *JNCI.* 1982;68:755-760.
15. Selikoff IJ, Hammond EC. Asbestos-associated disease in United States shipyards. *CA.* 1978; 28:87-99.
16. Steineck G, Carstensen J, Wiklund K. Mesothelioma among sugar refinery workers. *Lancet.* 1983;2:1503.
17. Watt BK, Merrill AL. Composition of Foods-Raw, Processed, Prepared. US Department of Agriculture Handbook No. 8, U.S. Government Printing Office. 1963; pp. 1-237.
18. Yano K, Reed DM and McGee DL. Ten-year incidence of coronary heart disease in the Honolulu Heart Program. *Am J Epid.* 1984;119:5:653-666.

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ENDARTERECTOMY AND SHUNT: ALTERNATIVES OR IN TANDEM?

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We sent the final copy for peer review to a local vascular surgeon. Here is the reviewer's comment:

"It is quite interesting to see what has been done in their [Siberian] large, centralized institutions; this collection of 567 patients with peripheral arterial occlusive disease is a very good example.

"From a scientific standpoint, the paper would not stand up to major scrutiny for peer review from one of our major vascular journals. However, when the source of the paper is placed in perspective, the statistics do become of considerable interest. One would have to question whether the series of endarterectomies versus the shunt procedures were randomized in some fashion, or whether a selection process took place. The follow-up of 2 to 5 years really represents early results in the majority of patients. The technique of endarterectomy utilizing the Vollmar rings is one that is practiced in Europe but is not practiced very often in the United States to my knowledge.

"The bottom line of rather similar results between the 2 techniques has been reported in our literature. Some of the numbers might be a bit different, but all in all the net results seem similar between the experience reported here (in the article above) and much of the reported experience from America.

"...I think it would be interesting to many readers of the Hawaii Medical Journal. I don't think a great deal of editing would be appropriate or necessary to justify publication. Actually, it probably would be impossible to get reliable data."

We add one additional comment: The principal author, Igor Andrievskikh, together with the Chelyabinsk Hospital's chief radiologist Vyasheslav Sharov, were in Hawaii in March 1993. They spoke to several groups about Chelyabinsk's major problem with the release of radionuclides from the Mayak nuclear weapons manufacturing complex in the southern Ural mountains (Chelyabinsk-70). Probably of greater interest to their listeners were the accounts of life and the practice of medicine in Russia. Igor was fortunate enough to witness a balloon coronary angioplasty performed at Queen's. He was shocked after seeing the $650 catheter being discarded. "We would have cleaned it and sterilized it for repeated use," he expostulated; "such a rare and expensive thing, in our country."

J I Frederick Reppun MD

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